SUBSTANTIALLY FAT FREE PRODUCTS FROM WHOLE STILLAGE RESULTING FROM THE PRODUCTION OF ETHANOL FROM OIL-BEARING AGRICULTURAL PRODUCTS

Docket No. 1.913.2

Cross –Reference To Related Applications

This application is a continuation-in-part of USSN 10/281,490 filed October 28, 2002.

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] This invention relates a process for obtaining substantially fat free products from whole stillage produced during ethanol production from agricultural products, such as cereal grains. More particularly, at least a portion of the fat is removed from both the thin stillage stream and the wet distillers grains that result from whole stillage.

Description of Related Art

[0002] In a conventional ethanol production process utilizing corn as the starch containing feedstock, the corn is ground to produce a milled corn. This is typically achieved by the use of a hammer mill or other suitable milling equipment. Water and enzymes are added to the milled corn and heated to form a mash. The mash is then mixed in a fermentation vessel with water, yeast and optionally minerals and nutrients to enhance the fermentation of the mash. The resulting fermented product, commonly referred to as the "beer", is then distilled to produce an ethanol rich stream (about 95% ethanol and 5% water by weight) and whole stillage. The whole stillage comprises water, as well as the solids left over from the fermentation. The whole stillag is typically centrifuged to remove a substantial portion of the water to form a solids rich fraction commonly referred to as wet distillers grains and a substantially liquid fraction commonly referred to as thin stillage. The wet distillers grains fraction includes most of the protein-containing solids from the whole stillage. It also contains about 8 to 12 wt.% fat. The thin stillage fraction, after evaporation to form a syrup, will typically contain from about 8 to 15 wt.% a fat. This syrup is also referred to as condensed distillers solubles (CDS), and is typically combined with the wet distillers grains and sent to a dryer to produce a dry protein containing animal feed called distiller dried grain solubles (DDGS).

[0003] Conventional ethanol processes have several significant problems. One problem is the energy costs to remove water from the whole stillage to produce a low economic value DDGS. A second problem is the environmentally unacceptable amount of volatile organic compounds (VOC), air toxics, and combustion pollutants, such as CO, NO_x, and particulate matter, released into the atmosphere during conventional drying methods. To achieve an acceptable levels VOC, air toxics, and combustion pollutants release amount requires large capital investments in thermal oxidizers and other equipment to capture the VOC, air toxics, and combustion pollutants released during conventional drying methods, as well as expensive equipment maintenance. Another problem, depending on the end use of the stream, is that the fat content for both the thin stillage fraction and the wet distillers grains fraction can be considered too high. These problems have hampered the commercial success of ethanol production processes that have to date, remained economically viable due only to governmental subsidies.

OBJECTS AND SUMMARY OF THE INVENTION

[0004] One object of the present invention is to provide an improved ethanol production process that results in value added flavor enhancing, nutritional, nutraceutical, and/or pharmaceutical by products.

[0005] Another object of the present invention is to provide an improved ethanol production process that minimizes the amount of VOC and other pollutants released to the atmosphere during the treatment of the whole stillage.

[0006] Still another object of the present invention is to provide an improved ethanol production process resulting in an oil stream, which oil stream is obtained from dried distillers grains, thin stillage, syrup resulting from thin stillage, or a mixture thereof.

[0007] Other objects and advantages of this invention shall become apparent from the ensuing descriptions of the invention.

[0008] Accordingly, an improved ethanol producing process is disclosed wherein a starch-containing feedstock, preferably a cereal grain such as corn, is processed to produce ethanol and whole stillage. The whole stillage comprises solids, nutrients, yeast and water remaining after the ethanol has been distilled off. The whole stillage is centrifuged, filtered or otherwise separated by

any suitable technique to produce a substantially solids stream and a substantially liquid stream. The substantially solids stream is referred to as wet distillers grains and contains most of the protein-containing solids, from about 8 to about 12 wt.% fat or oil, and water. The substantially liquid stream, referred to as the thin stillage will comprise the nutrients, yeast and most of the water from the whole stillage. The thin stillage is typically subjected to an evaporation step remove water and produce a syrup that will contain about 7 to about 15 wt.% oil or fat. It is to be understood that no distinction is made herein between the terms "oil" and "fat" and the words can be used interchangeably herein.

[0009] The wet distillers grains are dried under conditions that do not denature the proteins contained in the distillers grains, and more preferably, under conditions that minimize volutizing organic components in the wet distillers grains. The drying conditions used will depend on a variety of factors. For example, when utilizing spray drying, these factors include the ease at which the wet distillers grains can be atomized, the humidity of the air in the drying environment, the temperature of the hot air used to dry the wet distillers grains, the temperature of the wet distillers grains when they enter the spray drier, and the contact time between the hot air and the atomized wet distillers grain. In a preferred embodiment, these factors are controlled to produce a protein-rich product having a water content of less than about 15% by weight. More preferably a protein-rich product is produced that is substantially free of oil, but that will require an oil removal step. It has been found that setting the temperature and contact time to achieve a hot air exhaust temperature between about 140° F and about 170° F will result in a protein-rich product containing less than about 15% water by weight and whose proteins have not been denatured. Under normal humidity conditions and using conventional spray drying technology an exhaust temperature in the above range should result in an inlet hot air temperature of less than about 450° F, and a contact time of less than about three minutes. Utilization of the above drying conditions will also reduce the VOC emissions to the atmosphere. In a preferred embodiment the drying conditions are set to maintain the temperature of the wet distillers grains at an effective temperature that is low enough so that the amount of VOCs emitted will be less than the environmental regulations permit. It is preferred that a temperature be used wherein substantially no VOCs are emitted. It is further preferred that any VOC that is volatized pass through a cold trap and then filtered to remove water to produce a VOC product. The VOC product can then be utilized as a supplement to flavor enhance other products.

[0010] The dried distillers grains can be subjected to an oil removal step. It is preferred that an oil removal technique be used that will remove substantially all of the oil from the dried distillers grains. Non-limiting examples of oil removal techniques that can be used include centrifugation, pressing with and without the use of a solvent, and solvent extraction without the use of pressing. The preferred solvent for solvent extraction is a normally gaseous solvent, more preferably butane, propane, or mixtures thereof. By normally gaseous we mean a solvent in which the oil is soluble and being in the gas phase at atmospheric pressure and at room temperature (approximately 75°F).

[0011] The syrup can be added to the wet distillers grain prior to the drying step and be processed under the same conditions as the wet distillers grains as described above. An oil removal step can be performed on either the thin stillage before evaporation or on the syrup after evaporation. If performed prior to evaporation, an oil removal process such as centrifugation is preferred whereas after evaporation a solvent extraction process is preferred to extract at least a portion of the oil from the syrup.

[0012] In another alternate embodiment the thin stillage stream is not subjected to oil removal and is passed through a microfiltration unit utilizing a filter size to form a carotenoid containing retentate and a nutrient rich permeate. A filter having a pore size of about 0.1 to 1.0 micron can be used. The carotenoid containing retentate is then dried to produce a carotenoid rich product having less than about 15% water by weight. It has been found that setting the temperature and contact time to achieve a hot air exhaust temperature between about 140° F and about 170 ° F will result in a carotenoid rich product containing less than about 15% water by weight. Under normal humidity conditions and using a conventional spray dryer an exhaust temperature in the above range should result in an inlet hot air temperature of less than about 450° F, and a contact time of less than about three minutes. In a preferred embodiment any volatized VOC is passed through a cold trap and filter to produce a liquefied VOC product.

[0013] In yet another alternate embodiment the nutrient rich permeate is passed through an ultrafiltration unit utilizing a filter size to form a protein and yeast containing retentate and vitamin and mineral containing permeate. A filter having a pore size of less than about 0.1 microns is preferred. The protein and yeast containing retentate is dried to produce a protein and yeast rich product having less than 15% water by weight. It has been found that setting the temperature and

contact time to achieve a hot air exhaust temperature between about 140° F and about 170 ° F will result in a protein and yeast rich product containing less than about 15% water by weight and whose proteins have not been denatured. Under normal humidity conditions and using a conventional spray dryer an exhaust temperature in the above range should result in an inlet hot air temperature of less than about 450° F, and a contact time of less than about three minutes. The vitamin and mineral containing permeate can also be dried under the same conditions as the protein and yeast containing retentate to produce a vitamin and mineral rich product having less than 15% water by weight. It is preferred that any volatized VOC's be passed to a cold trap and filter to produce a liquid VOC product.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The accompanying drawings illustrate a preferred embodiment of this invention. However, it is to be understood that this embodiment is not intended to be exhaustive, nor limiting of the invention. They are but examples of some of the forms in which the invention may be practiced.

[0015] Figure 1 is a schematic illustrating a conventional ethanol production process, but with oil removal steps on products resulting after centrifugation of the whole stillage.

[0016] Figure 2 is a schematic illustrating a preferred embodiment of this invention to treat the wet distillers grain to produce a non-denatured protein rich product.

[0017] Figure 3 is a schematic illustrating a preferred embodiment of this invention to treat the thin stillage through use of microfiltration to produce a carotenoid rich product.

[0018] Figure 4 is a schematic illustrating a preferred embodiment of this invention to treat the permeate stream from the microfiltration through use of ultrafiltration to produce a protein/yeast rich product and/or a vitamin/mineral rich product.

DETAILED DESCRIPTION OF THE INVENTION

[0019] Without any intent to limit the scope of this invention, reference is made to the figures in describing the preferred embodiments of the invention utilizing corn as the starch containing feedstock. The process described herein can also be used with other starch containing feedstocks such as bagasse, sugar cane, grains, and other oil-bearing starch or sugar based materials.

[0020] In a typical ethanol production process as illustrated in Figure 1, a starch-containing feedstock **1**, such as corn, is fed to a grinder **2** to produce a milled corn **3**. The milled corn **3** is then sent to a mixer **4** where water **5**, as well as enzymes **6**, are added to produce a liquid mash **7**. The liquid mash **7** is then sent to a fermentation vessel **8** where the desired yeast and additional enzymes **9**, as well as the minerals and nutrients **10** if necessary for efficient fermentation, are added. After an effective amount of fermentation time a "beer" is produced and is sent to distillation unit **12** where an ethanol rich (about 95% ethanol by weight) stream **13** is separated from the remaining fermented solids and water. The remaining fermented solids and water is generally known as the whole stillage **14**. The whole stillage **14** is processed to produce an animal feed commonly known as DDGS. The conventional method of treating whole stillage **14** is conduct it to a centrifuge **15** to form two separate streams, a substantially solids stream and a substantially liquid stream. The substantially solids stream is referred to as the wet distillers grains fraction **16**. The substantially liquid stream is referred to as the thin stillage fraction **17**. The wet distillers grains fraction **16** is comprised of most of the solids, protein, water, and about 8 to 12 wt.% oil. The thin stillage stream **17** is substantially all water with some oil and up to about 10 wt.% solids. It includes the minerals, nutrients, yeast and the remaining water that was found in the whole stillage **14**. In a typical process, the thin stillage stream **17** is sent to evaporator **18** where water **19** is removed and the remaining solids or syrup **20** are combined with the wet distillers grain **16** and sent to a dryer **21**. In the improved process of the present invention oil can removed at various stages of the process. For example, the wet distillers grains can be passed to oil removal step **16A** wherein at least a portion of the oil is removed. Since the wet distillers grains still contain a significant amount of water, it is preferred to remove the oil by a centrifugation process wherein the wet distillers grains are introduced into a centrifuge apparatus and centrifuged at an effective speed and amount of time to cause oil to be removed from the wet distillers grains. The resulting liquid products from centrifugation will be predominantly comprised of water and oil, which can be separated from each other by any suitable oil/water separation technique. For example, the oil/water mixture can be conducted to a decanting tank and allowed to sit for an effective amount of time to allow phase separation to occur. That is for an oil phase and a water phase to form. The oil phase can then be easily decanted. It is also within the scope of this invention that the oil/water mixture be passed through a countercurrent vessel containing one or more suitable vertically disposed distribution trays wherein a solvent, such a C_2 to C_6 alkane is passed counter to the flow of the oil/water mixture. The oil will be taken up in the solvent and be

carried with the solvent to a separation vessel wherein the solvent can be flashed or distilled from the oil and recycled.

[0021] The wet distillers grains can also be dried via dryer **21** to produce a dried distillers grains fraction which can then be subjected to oil removal via **24A**. Oil removal step **24A** can be any suitable oil removal process including centrifugation, but solvent extraction is preferred. The dried distillers grains can be first pressed before solvent extraction. That is, the dried distillers grains can be put in a suitable press and a substantial amount of oil removed via pressing. At least a portion of the remaining oil can be removed by subjecting the pressed grains to a suitable solvent, preferably a normally gaseous solvent, more preferably one selected from butane, propane and mixtures thereof. Since the solids of the wet distillers grains originate from the milling of the cereal grain, it is unlikely that pressing will be needed to remove the oil.

[0022] Dryer **21** is typically operated with hot air having an inlet temperature at about 1000° F. - 1200° F. The hot air will remain in contact with the wet distillers grain **16** and syrup **20** for an effective amount of time, which will typically be from about 3 to 10 minutes, more preferably from about 4 to 6 minutes before exiting the dryer **20** having an exhaust temperature at about 200° F. - 225° F. At these conditions the protein contained in the dried solids **24** are denatured and are only good for use in animal feed known as DDSG. In addition any water vapor **22** and VOC **23** in the wet distillers grain **16** and syrup **20** is volatized and either released to the atmosphere or passed through expensive conventional thermal oxidizers (not shown).

[0023] Both the thin stillage and syrup can each be individually, or a mixture thereof, conducted to an oil removal step, **17A** and **20A**. For example, the thin stillage can be centrifuged in a similar manner as the wet distillers grains and the resulting oil/water mixture sent to a separation zone wherein the water is separated from the oil. As mentioned previously, separation can be done by simple decanting, by distilling the water from the oil, or by passing a solvent, in which the oil is at least partially soluble or misible, can be run counter current with the flow of mixture, which solvent will pickup the oil and carry it in the opposite direction than the water. If using solvent extraction it is preferred that the material being oil-extracted be substantially dry. For example, it is preferred to dry the syrup by any suitable means, preferably by spray drying, before subjecting it to a solvent.

[0024] As previously mentioned, the preferred solvent for solvent extraction is a normally gaseous solvent. As previously mentioned, butane, propane, and mixtures thereof are preferred with propane being the more preferred. Non-limiting examples of other solvents that can be used include: methane, ethane, ethylene, propylene, butylene, sulfur dioxide, carbon dioxide, CHF_3, $CClF_3$, $CFBr_3$, $CF_2{=}CH_2$, CF_3-CF_2-CF_3, CF_4, CF_4, CH_3-CF_3, $CHCl_2$, ammonia, nitrogen, dichlorodifluor methane, dimethylether, methyl fluoride, and halogenated hydrocarbons that are normally gaseous as indicated.

[0025] If solvent extraction is used it can be conducted in either batch, semi-batch or continuous mode, with continuous mode being preferred. By semi-batch we mean that the process unit will contain several extraction vessels, wherein there will always be one extraction vessel off line and being emptied of treated product while the other one or more extraction vessels will remain on line. When it is time to unload treated product from one of the reactors on line, such extraction vessel will be taken off line and the extraction vessel that was off line will take its place on line. In one preferred method for practicing batch solvent extraction, the material to be extracted is introduced into a suitable extraction vessel. Air is removed from the vessel and a normally gaseous solvent is introduced wherein it is pressurized, preferably by continuing to introduce solvent into the closed vessel until the normally gaseous solvent is converted to the liquid state. The oil will then dissolve in the liquid solvent and the solution of oil and solvent will be conducted from the extraction vessel to a separation vessel where the solvent will be removed from the oil by flashing or distillation. It is preferred that the oil in solvent solution be passed from the extraction vessel to the separation vessel while the solvent is still in the liquid state. It is also preferred that a vacuum be used to remove remaining solvent from the deoiled material as well as being used to aid in the removal of air from the extraction vessel prior to introduction of solvent.

[0026] Any suitable continuous solvent extraction mode can be used in the practice of the present invention. For example, the material (syrup) to be extracted can continuously be fed at an effective rate, into a pressure sealed extraction vessel by any suitable means, such as by use of an auger feeding mechanism. Solvent can continuously be added to contact fresh syrup to be extracted and the resulting oil in solvent solution can continuously be removed and the solvent separated from the oil as previously mentioned.

[0027] In one preferred embodiment, the process of this invention involves improved treatment of the whole stillage **14** to produce products each having greater economic value than DDGS, as well as significantly reduce the costs of treatment of the emissions from the process. In particular the amount of VOC emissions can be reduced while at the same time producing a flavor enhancement supplement product. Turning now to Figure 2, the whole stillage **14** is again separated into two product streams by centrifuge **15**. Other known separating equipment such as filters could be used. These two streams include the wet distillers grains **16** containing oil and most of the protein compounds found in the whole stillage **14** and the thin stillage stream **17** also containing oil, as well as most of the carotenoid, yeast, vitamin, mineral, and remaining protein compounds.

[0028] The wet distillers grain **16** is sent to a drying step **21** that is operated at conditions controlled to produce a protein rich product having a water content of less than about 15% by weight. Non-limiting examples of suitable drying means include spray drying, fluidized bed drying, single and double drum dehydrating, use of ring drier or other suitable means to produce a substantially free flowing solid. It is preferred that the drier can be a spray drier. It has been found that setting the temperatures of the hot air and the wet distiller grain **16**, as well as their contact time to achieve a hot air exhaust temperature of between about 140° F. and about 170° F. will result in the production of a protein rich product **23** having a water content of less than about 15% by weight. Under normal humidity conditions a hot air exhaust temperature in the above range would likely require an inlet hot air temperature of less than about 450 ° F., and a contact time of less than about three minutes. Within these drying conditions the wet distillers grain temperature should remain below the temperature to volatize most, if not all, of the VOC contained in the wet distillers grain. Thus, a significant portion of the VOC will remain in the protein rich product **23**. This has the result of not only reducing the VOC that are volutized, but maintaining more of the flavor enhancing compounds in the protein rich product **23**. It is also preferred that the protein rich product **23** be cooled upon leaving dryer **21** to prevent any further volutization of the VOC that is contained in the protein rich product **23**. One method of cooling the protein rich product **23** is through the use of a fluidized bed wherein cool or ambient temperature air is used to fluidize the bed. Other known cooling techniques could be employed. This protein rich product **23** can also be subjected to an oil removal step (not shown) as previously mentioned.

[0029] The water and any VOC vapor **22** removed during drying can be recycled to the mixer **4**. Depending on the dryer operating conditions some VOC may be volatized. Because the volume of the volutized VOC is substantially less than in a conventional whole stillage treatment process, the water and VOC vapor **22** can be sent through a conventional and less expensive cold trap **24** to produce a liquid VOC product **25**. Water **26** in the liquid VOC product **25** can be removed, such as by filter **26** or other known separating equipment, to produce a dry VOC product **28** that can be sold as a flavor enhancing additive.

[0030] Turning now to Figure 3 in another preferred embodiment the thin stillage **17**, without oil removal, is passed through a microfiltration unit **29** having a filter size of about 0.1 to 1.0 micron to form a retentate stream **30** and a permeate stream **31**. In a more preferred embodiment the filter size is set to capture in the retentate stream **30** the carotenoid compounds. Carotenoid compounds, particularly Lutien and Zeaxantin, have been found useful in reducing various serious eye diseases such as age related macular degeneration and cataracts. The retentate stream **30** containing the carotenoid compounds is sent to dryer **32**. If desired, this carotenoid rich product can also be subjected to an oil removal step (not shown) as previously mentioned. In a preferred embodiment dryer **32** will be operated at a temperature to minimize the denaturing of any protein contained in the retentate stream **30**, as well as to prevent volatization of the VOC's in the retentate stream **30** during the period that the retentate stream **30** is contained in the dryer **32**. This can be achieved if the retentate stream **30** is retained in dryer **32** for a period of less than about three minutes, and the dryer **32** is operated with a hot air exhaust temperature less than about 170 ^{o} F to remove the water. Operated in this manner sufficient water can be removed to form a carotenoid rich product **34** having less than 15% water by weight. Depending on the dryer operating conditions and the retention time of the retentate stream **30** in the dryer **32** some VOC may be volatized. Because the volume of the VOC is substantially less than in a conventional whole stillage treatment process, the water and VOC vapor **33** can be sent through a conventional and less expensive cold trap **35** to produce a liquid VOC stream **36**. Stream **36** can be recycled to mixer **4** or preferably the liquid VOC can be separated from the water **38** in stream **36** by a filter **37** to produce VOC product **39** that can be sold as a flavor enhancing additive.

[0031] Turning now to Figure 4 in another preferred embodiment the permeate **31** is passed through an ultrafiltration unit **40**. The filter size is selected to be less than about 100,000 molecular

weight to produce a protein and yeast rich retentate **41** and a vitamin and mineral rich permeate **42**. By less than 100,000 molecular weight we mean that the filter is one that components less than about 100,000 molecular weight will pass. The protein and yeast rich retentate **41** is sent to dryer **43** to remove at least a substantial portion of the water from the retentate **41**. It is preferred that the dryer **43** be operated to minimize the volalization of any VOC's in the retentate **41**. This can be achieved by utilizing the same operating conditions as described above for dryer **32**. Operated in this manner sufficient water can be removed to form a protein and yeast rich product **45** having less than 15% water by weight. Depending on the dryer operating conditions and the retention time of the protein and yeast retentate **41** in the dryer **43** some VOC may be volatized. Because the volume of the VOC is substantially less than in a conventional whole stillage treatment process, the water and VOC vapor **44** can be sent through a conventional and less expensive cold trap **48** to produce a liquid VOC stream 49. Stream **49** can be recycled to mixer **4** or preferably the water **51** in stream **41** can be separated by filter **50** to form a VOC product **52** that can be sold as a flavor enhancing additive.

[0032] In another preferred embodiment the vitamin and mineral rich permeate **42** is sent to the dryer **46** to remove at least a substantial portion of the water in permeate **42**. It is preferred that the dryer **46** be operated to minimize the volalization of any VOC's in the permeate **42**. This can be achieved by operating dryer **46** under the same conditions as dryer **43**. Operated in this manner sufficient water can be removed to form a vitamin and mineral rich byproduct **47** having less than 15% water by weight. Depending on the dryer operating conditions and the retention time of the permeate **42** in the dryer **46** some VOC may be volatized. Because the volume of the VOC is substantially less than in a conventional stillage treatment process, the water and VOC vapor can be sent through a conventional and less expensive cold trap **48** to produce a liquid VOC stream similar to stream **49**. This stream can also be recycled to mixer **4** or passed through a filter, such as filter **50**, to form a VOC product that can be sold as a flavor enhancing additive.

[0033] Thus, as shown in the Figures 2-4, the whole stillage **14** can be processed to produce a protein rich product **23**, a carotenoid rich product **34**, a protein and yeast rich product **45**, and a vitamin and mineral rich product **47** with minimum or no VOC's released to the atmosphere. The VOC's produced do not have to be treated by expensive thermal oxidizers or similar equipment, but can be sent to a less expensive cold trap and filter to produce yet another value added product, liquid

VOC's. Each of these five product streams has significantly greater commercial value than the currently produced animal feed DDGS.

[0034] It is not necessary that separate cold traps be used for each of the product streams. Depending on the amount of VOC volatized, the different VOC streams volatized can be combined and sent to one or more of the cold traps, thus further reducing capital expense. Depending on the product desired it is also possible to direct various streams to a common dryer. There are of course other alternate embodiments that are obvious from the foregoing descriptions of the invention which are intended to be included within the scope of the invention as defined by the following claims.

[0035] In another preferred embodiment of the present invention the thin stillage is dried to a substantially free flowing powder by any suitable drying means. Non-limiting examples of suitable drying means include spray drying, fluidized bed drying, single and double drum dehydrating, use of ring drier or other suitable means to produce a substantially free flowing solid. It is preferred that the drier can be a spray drier. It is preferred that the water content of the thin stillage be first reduced by one or more dewatering steps, such as evaporation, prior to being subjected to the drying means. The dewatering step(s) is distinguished from the drying step since the drying step is performed at elevated temperatures and the dewatering is done by lower temperature operations that include gross water separation, such as by pressing, evaporation, etc. After drying, the resulting free flowing powder will contain 15 wt.% or less water, based on the total weight of the final dried product. It is preferred that the water content of the final product be from about 10 wt.% to about 15 wt.%. It is also preferred that the drying be done at an effective temperature and for an effective amount of time. By effective temperature we mean that temperature that is effectively low so that desirable ingredients, such as proteins, are not destroyed but not so low that drying takes an uneconomical amount to time. Such temperatures will be less than about 170°F, typically from about 140°F to about 170°F. An effective amount of an additive can be introduced into the thin stillage stream prior to drying or it can be introduced into the drying means simultaneously with the thin stillage. The additive can be any ingredient in an amount that is needed to produce a final dried product having the desired properties for its intended end use. Non-limiting end uses can be an ingredient for a pet food or for human consumption. Non-limiting examples of such additives are selected from vitamins, minerals,

amino acids, proteins, flavors, phytochemicals, pharmaceuticals, nutraceuticals, binders and fillers, other streams resulting from the treatment of cereal grains, and mixtures thereof. It is to be understood that the free flowing syrup powder can also be subjected to an oil removal step as previously described.